MARELLI

Engineering the Future of Propulsion

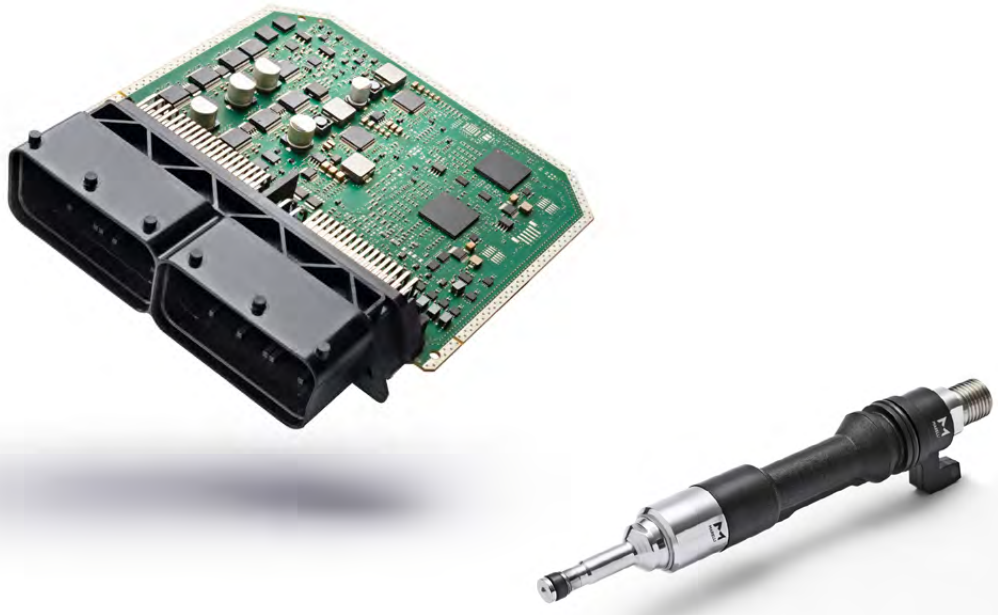

TABLE OF CONTENTS

Click any heading to view the section

ENGINEERING THE FUTURE OF PROPULSION page 03

ELECTRIFICATION CONTEXT page 04

MARELLI: ENGINEERING ICE SOLUTIONS page 05

1. **Fuel and injection systems** page 06
   - Gasoline Direct Injection page 07
   - PFI Injector page 08
   - Flex Fuel System page 09
   - Product spotlight: Ethanol Sensor page 09
   - Hydrogen Direct Injection page 10
2. **Engine and vehicle control systems** page 11
   - Engine Management Systems page 12
   - Vehicle Management Systems page 13
   - Domain Controller page 13
   - Multi-Domain Controller page 14
3. **Air, thermal and powertrain integration** page 15
   - Air Intake Manifolds page 16
   - Throttle Bodies page 17
   - Mechatronic Actuators page 18
   - Product spotlight: Matrix Actuator page 19
   - Integrated transmission control systems page 20

MARELLI: ADVANCING SUSTAINABLE PROPULSION WORLDWIDE page 21

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ENGINEERING THE FUTURE OF PROPULSION

A century of combustion expertise, evolved for the next generation of efficient, hybrid and multi-fuel powertrains

Supporting OEMs from conventional internal combustion engine (ICE) architectures to hybrid and region-specific powertrain strategies.

PROVEN HERITAGE



100+ years of combustion expertise

Supported by high-volume production, global manufacturing and proven OEM applications.

COMPLETE SYSTEM CAPABILITY



From component to system integration

Fuel, air, thermal and transmission management with integrated controls, software and calibration.

GLOBAL REACH, LOCAL SOLUTIONS



Global scale with local adaptability

Scalable architectures and localized engineering for diverse fuels, regulations, costs and market needs.

FAST, LOW-RISK DEVELOPMENT



Accelerating time to market

Pre-developed technologies with validation, calibration, homologation and digital engineering support.

Marelli by the numbers

100+ YEARS of engine expertise	**100M+** PFI Injectors produced	**150M+** Throttle Bodies deployed
20+ YEARS of flex-fuel expertise	**40%** PFI Injector market share in South America	UP TO **40%** faster development with Digital Twin

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ELECTRIFICATION CONTEXT

Automotive electrification is progressing at different speeds across regions and vehicle segments, resulting in a multi-powertrain landscape in which ICE technologies continue to play a more significant role than many forecasts predicted.

OEMs must therefore align global programs with sustained ICE demand while meeting strict emissions targets and diverse regional requirements. This requires continuous advancement across all areas of powertrain development, from combustion optimization and hybrid integration to compatibility with alternative fuels.

With more than a century of combustion-engine heritage, Marelli remains fully committed to advancing ICE technology. This brochure outlines how Marelli acts as both system integrator and technology partner, delivering adaptable, high-efficiency ICE architectures engineered for the global programs of today and tomorrow.



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MARELLI: ENGINEERING ICE SOLUTIONS

Across global powertrain programs, OEMs face two competing pressures: investing heavily in zero-emissions powertrain development while continuing to support resilient demand for ICE vehicles, with regulations, infrastructure, fuel availability and customer preferences varying significantly across markets.

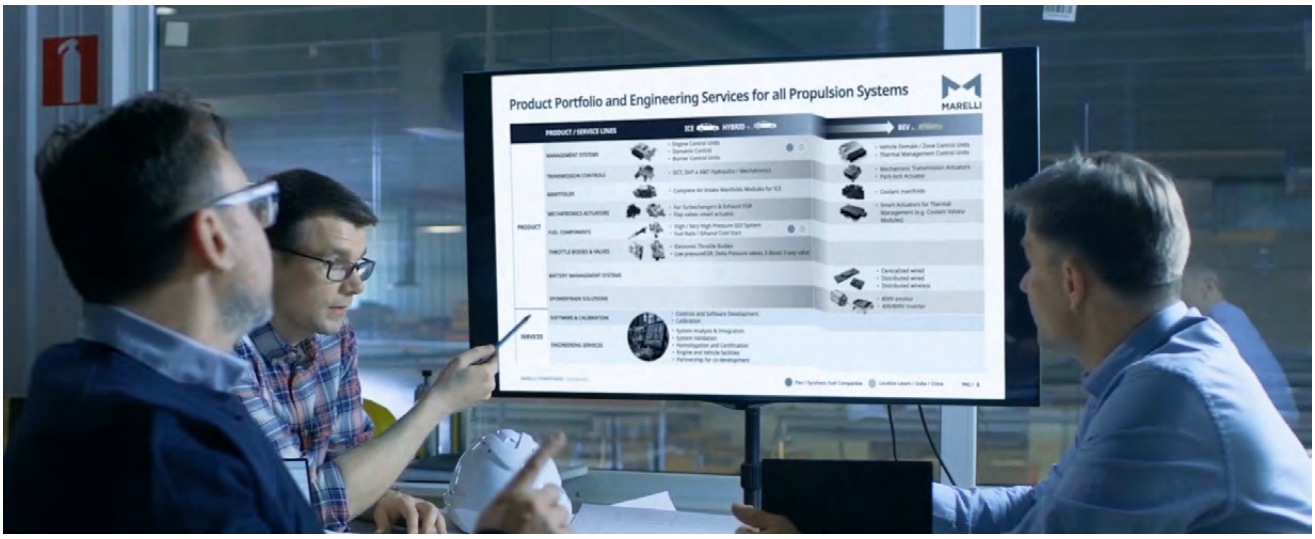
The result is more focused investment in fewer ICE platforms, with each architecture expected to deliver greater efficiency, flexibility and cost competitiveness across multiple regions and vehicle applications.

To address this challenge, Marelli enables OEMs to extend the value of core ICE platforms across multiple applications and markets. Modular, scalable solutions help balance performance, emissions, cost and regional requirements while reducing the need for market-specific architectures.

With engineering and manufacturing operations across Europe, North and South America, China, India, Japan, and Southeast Asia, Marelli supports global vehicle programs while adapting solutions to local regulations, fuel strategies, cost targets and market requirements.

Marelli's end-to-end capabilities span fuel and injection systems, engine and vehicle control systems, air and thermal management, mechatronic actuation and powertrain integration. From individual components and software applications to complete system-level integration, Marelli helps OEMs accelerate development, reduce complexity and bring efficient, future-ready powertrains to market.

Sustainable ICE is a core strategic pillar of **Marelli Propulsion**, bringing together three complementary technology areas: **fuel and injection systems, engine and vehicle control systems, air, thermal and powertrain integration.**



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1. Fuel and injection systems

Combustion precision and multi-fuel flexibility

Marelli's fuel and injection systems support precise fuel delivery across a wide range of engine architectures and fuel types, including ethanol and methanol.

Scalable Gasoline Direct Injection (GDI) and Port Fuel Injection (PFI) technologies enable Marelli to address diverse fuel strategies and performance requirements, from conventional gasoline applications to flex-fuel and emerging low-carbon solutions.

Gasoline Direct Injection	page 07
PFI Injector	page 08
Flex Fuel System	page 09
Product spotlight: Ethanol Sensor	page 09
Hydrogen Direct Injection	page 10



Gasoline Direct Injection (GDI)

GDI is the dominant fuel-injection technology in emissions-driven markets, delivering fuel directly into the combustion chamber for precise, high-pressure combustion control.

Marelli's modular GDI portfolio comprises injectors, high-pressure fuel pumps, fuel rails, Engine Control Units (ECUs) and software, **with high-pressure capability extending to 1,000 bar**. This provides significant headroom beyond the 350 to 500 bar range of today's most advanced mainstream GDI injectors, while supporting best-in-class noise and dynamic performance.



OEM benefits

Efficient combustion - Precise control of fuel quantity, timing, pressure and atomization for lower fuel consumption and CO_2 emissions.

Architecture flexibility - Modular, scalable architecture includes central or side-mounted injection and a choice of injector tip configurations.

Cost-effective adoption - Cost-focused component design, including a new fuel-pump body that can reduce overall pump cost by around 20% for best-in-class competitiveness.

Durability with reduced maintenance - Precise combustion control supports engine durability and can reduce maintenance requirements.

Technology highlights

100-1,000 bar pressure range	Complete GDI system: injector, pump, rail, ECU and software	Modular configuration for central or side-mounted applications	6 mm and 7.5 mm injector tips	Long-tip prototype injectors for pre-chamber and specific applications

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PFI Injector

Port fuel injection delivers fuel into the intake port before combustion, offering a proven route to precise fuel delivery. It remains important in regions and for applications where cost, simplicity and reliability are decisive.

Port fuel injection can support fuel-flexible applications and complement GDI in dual-injection architectures, helping balance fuel consumption and performance across different operating conditions.



With **more than 100 million injectors produced**, Marelli's PFI Injector family delivers a mature, high-quality solution meeting Euro 6 and ULEV/SULEV emissions requirements.

OEM benefits

Adaptable integration - Compact, lightweight construction and modular configuration ease integration across different engine architectures, reducing development complexity and time-to-market.

Calibration flexibility and refinement - Configurable spray geometry supports application-specific calibration, with low leakage, low noise and high-temperature fuel handling.

Optimized for alternative fuels - Compatible with gasoline, E100 ethanol and M15 methanol, while stainless-steel, corrosion-resistant construction addresses the durability demands of alternative fuels.

DATA & MARKET POSITION

40% market share

in South America

Strong growth outlook:

+200% expected in flex-/bi-fuel applications (5 years)

Production footprint supports:

- 4M+ PFI injectors/year
- 7.5M+ GDI injectors/year
- 3M fuel pumps/year

Technology highlights

Long, medium and short configurations with standard or extended tips	Minitimer, Sumitomo or USCAR connector options	5-10 bar pressure	Valve leakage ≤2 µl/min at 4 bar	Compatible with gasoline, E100 ethanol and M15 methanol

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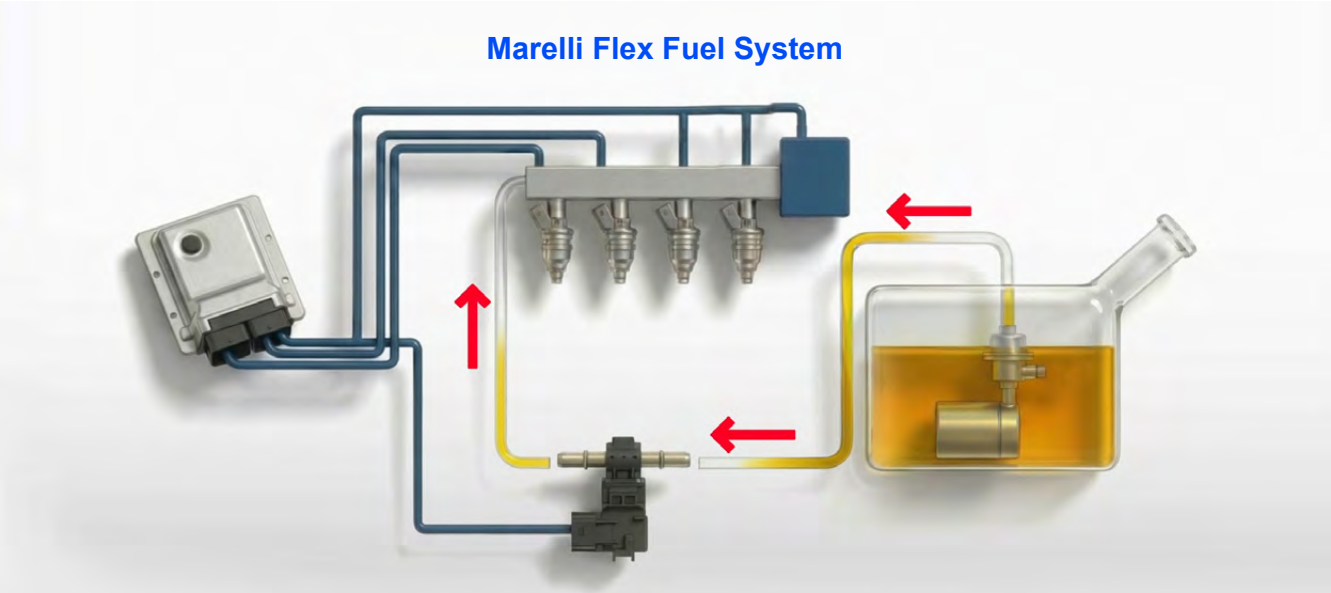
Flex Fuel System

Beyond individual injector and ECU functions, Marelli supports OEMs across biofuels, Compressed Natural Gas (CNG) and future hydrogen combustion, drawing on more than 20 years of market-leading expertise in flex-fuel technology. This capability combines fuel-system hardware, patented fuel management strategies and regional engineering support, helping ICE platforms adapt to changing fuel availability and local market demands.



Fuel from the tank passes through the ethanol sensor, which measures the ethanol concentration in the gasoline–ethanol blend in real time and sends the signal to the engine control unit. The ECU then automatically adjusts injection timing, ignition advance and cold-start strategy to optimize performance, fuel consumption and emissions across compatible fuel blends.

Product spotlight: Ethanol Sensor

Marelli's Ethanol Sensor measures ethanol percentage and fuel temperature, giving the ECU the data needed to optimize fuel management decisions. Combined with corrosion-resistant components and dedicated cold-start support for higher ethanol blends, Marelli helps OEMs address alternative-fuel requirements in key markets including Brazil and India, where flex-fuel and bi-fuel applications are expected to grow by more than 200% over the next five years.



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Hydrogen Direct Injection (H_2DI)

Marelli's H_2DI technology supports lower-emissions propulsion, while retaining the familiarity of a combustion-engine architecture. Building on patented high-pressure GDI expertise, Marelli's hydrogen fuel system combines the injector, software and ECU controller, enabling efficient hydrogen combustion with zero tailpipe CO_2.



OEM benefits

Performance, range, rapid refueling - Hydrogen can deliver faster acceleration, higher power output and better efficiency than comparable gasoline or diesel engines, with faster refueling and longer range than BEVs.

Demanding duty cycles - Ideal for long-distance commercial, continuous-duty and off-highway applications where BEVs may face practical limitations.

Durability and sustainability - Cleaner combustion can contribute to reduced engine wear and extended engine lifespan, while hydrogen produced from renewable energy sources supports lower well-to-wheel emissions.

Technology highlights

Hydrogen injector, software and ECU controller	Patented injector design derived from 1,000-bar GDI expertise	Static flow of 11 g/s at 40 bar	Engineered for durability and injection stability

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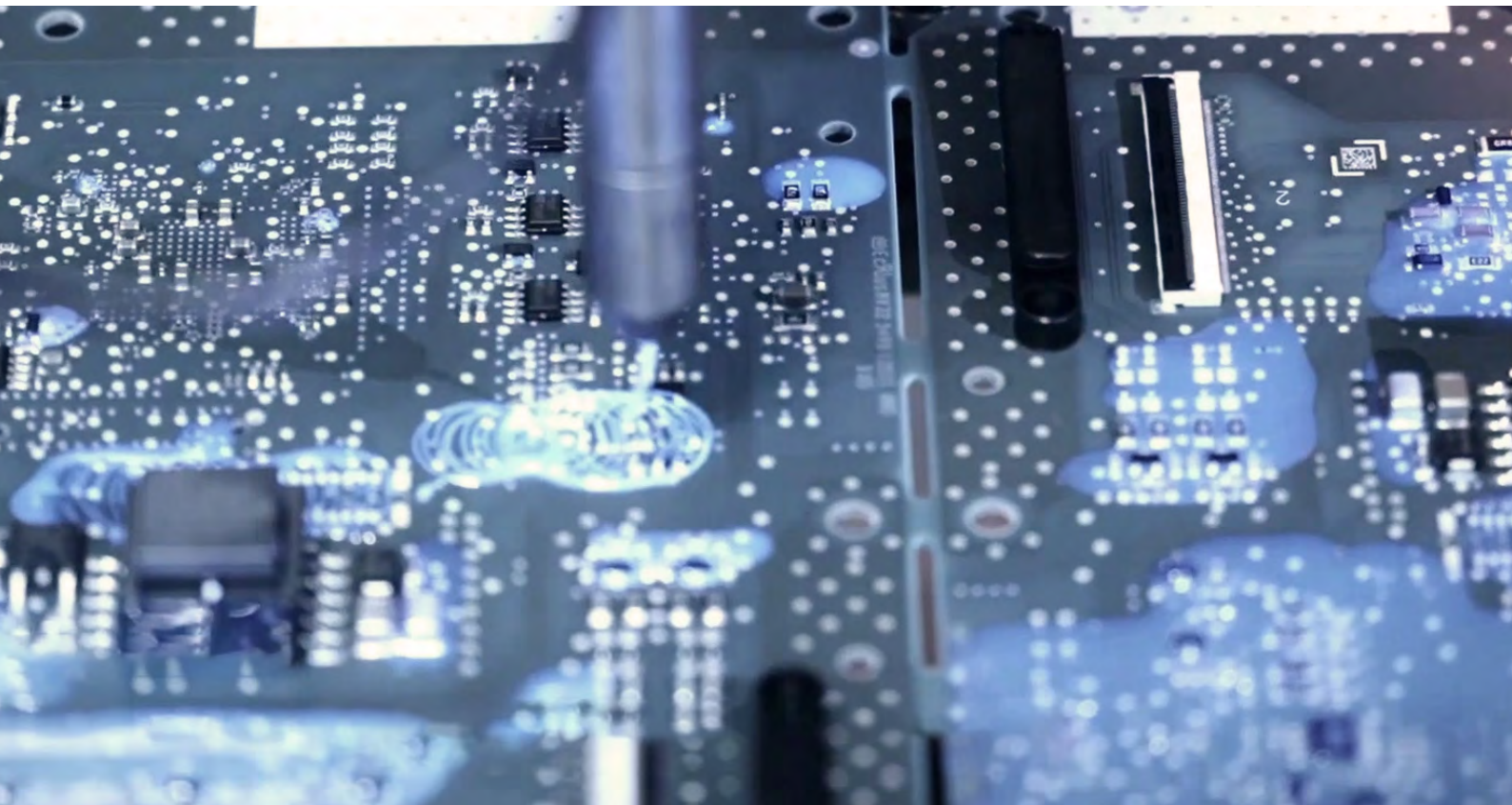
2. Engine and vehicle control systems

Intelligent software with system-level optimization

Marelli's engine and vehicle control systems form the intelligence layer of modern ICE and hybrid powertrains, spanning engine-level control through to vehicle-level coordination of powertrain, thermal and chassis functions.

Marelli systems combine control hardware, proprietary software and third-party application integration. Supported by regional development capability, these systems help OEMs adapt platforms to evolving emissions standards and the requirements of increasingly electrified and connected vehicles.

Engine Management Systems	page 12
Vehicle Management Systems	page 13
Domain Controller	page 13
Multi-Domain Controller	page 14



Engine Management Systems (EMS)



Marelli's Engine Management Systems (EMS) technology enables advanced combustion strategies across PFI and high-pressure GDI applications, including patented flex-fuel and bi-fuel solutions.

Featuring AURIX™ TC3x microprocessors, our EMS provides the faster processing, increased memory and multitasking capability required for advanced control strategies. Dynamic injection range extension software further improves GDI injector precision at very small injection quantities, helping reduce fuel consumption and emissions even in normally non-linear operating ranges.

The portfolio includes ECU hardware, software, calibration, homologation support and optional firmware over-the-air (FOTA) updates. Flexible software business models range from full application software to basic software.

OEM benefits

Advanced engine control - Precise management of combustion, injection and energy strategies optimizes efficiency, emissions and drivability across conventional ICE, alternative-fuel and hybrid applications.

Multi-fuel adaptability - Patented flex-fuel and bi-fuel strategies adapt engine control to changing fuel types and blends, supporting gasoline, ethanol, methanol, synthetic fuel and CNG applications.

Reduced calibration and development effort - Integrated ECU hardware, software, calibration and homologation support reduces development complexity and accelerates time-to-market.

Safety and security readiness - Functional safety support up to ASIL C, together with anti-tuning, cybersecurity and FOTA capabilities.

Technology highlights

Second-generation AURIX™ TC3x microprocessors	Dynamic injection range extension software for GDI injector control	Patented flex-fuel and bi-fuel control strategies	Region-specific ECU versions for EMEA, India and Brazil
Configurable I/O architecture for injector, valve, actuator and vehicle-system integration	ISO 26262 support up to ASIL C for engine management applications	Anti-tuning capability through Hardware Security Module functionality	Optional FOTA updates

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Vehicle Management Systems

Marelli is a leader in advanced Vehicle Management Systems, extending its engine-management expertise into vehicle-level control across propulsion, thermal management, hybrid system integration and chassis electronics.



Vehicle Management Systems coordinate sensors, actuators and controllers to support seamless operation across increasingly complex vehicle systems.

Marelli offers two key Vehicle Management System options: Domain Controllers and Multi-Domain Controllers.

Domain Controller

Marelli Domain Controllers consolidate related functions, such as propulsion, thermal management and hybrid energy management.

OEM benefits

Modular architecture - Modular, scalable design integrates related control functions, supporting lighter, simpler and more software-defined vehicle architectures.

Flexible actuator integration - High I/O capacity and actuator-driver capability support integration of valves, relays, motors and other controlled devices.

Safety-ready architecture - Robust, secure design for system reliability, functional safety and future-proofed regulatory compliance.

Technology highlights

Infineon TC3 microprocessors	ASIL C functional safety requirements	RCD wake-up capability
4 CAN and 2 LIN interfaces for subsystem communication	25 low-side drivers and 2 H-bridges for actuator and motor control	Cybersecurity-ready design

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Multi-Domain Controller

Marelli's Vehicle Domain Control Module (VDCM) consolidates control across propulsion, thermal management, transmission and chassis-related functions, supporting the industry shift toward multi-domain and zonal E/E architectures. The VDCM can manage functions directly through actuation or indirectly by communicating with dedicated control units.



OEM benefits

All domain-controller benefits, plus:

Integrated vehicle motion control - Coordinates longitudinal, vertical and lateral dynamics for integrated vehicle behavior across chassis, propulsion and braking, including self-leveling, semi-active and active suspension.

Fail-operational safety - ASIL D safety architecture combines dual microcontrollers and fail-operational redundancies to help manage driver inputs and support Level 3 automated-driving requirements.

Ready for zonal architectures - A first step toward zonal architectures, the module is designed to evolve through the future integration of gateway functionality, enabling compatibility with next-generation E/E architectures.

Technology highlights

Supervision of propulsion, chassis and transmission controls	Vertical and longitudinal dynamics control optimization	Torque coordination across ICE, hybrid and BEV powertrain architectures	Gateway functionality and frontal-zone power-distribution readiness

Gear selector, Parklock and transmission control functions	ADAS, diagnostics and safety functions	Fuel-consumption optimization strategies	Future front-controller capability for centralized zonal E/E architectures	Thermal and energy management

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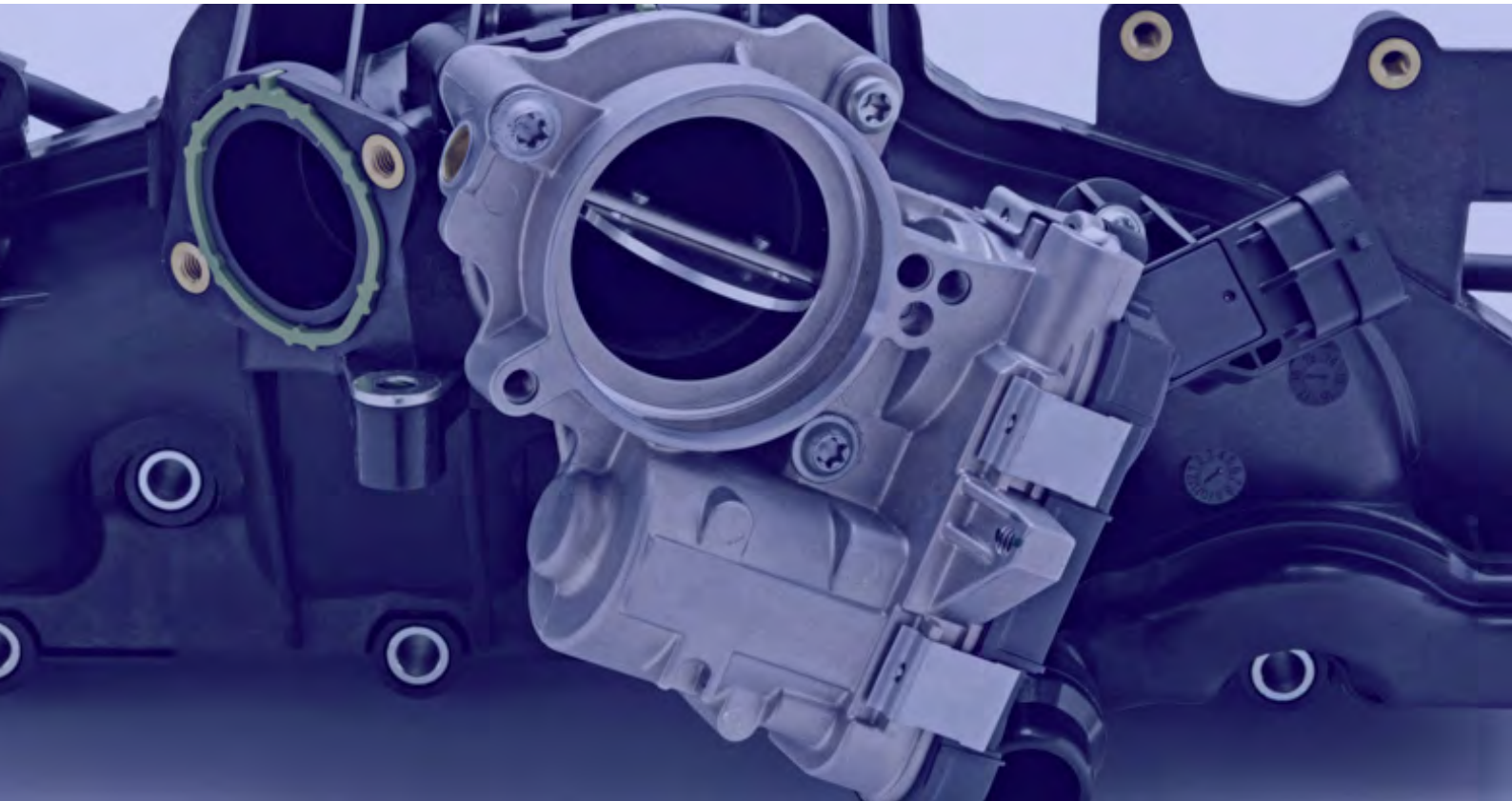
3. Air, thermal and powertrain integration

Maximizing efficiency, performance and hybrid readiness

Marelli's air, thermal and powertrain integration solutions enable efficient ICE operation and cost-effective hybridization.

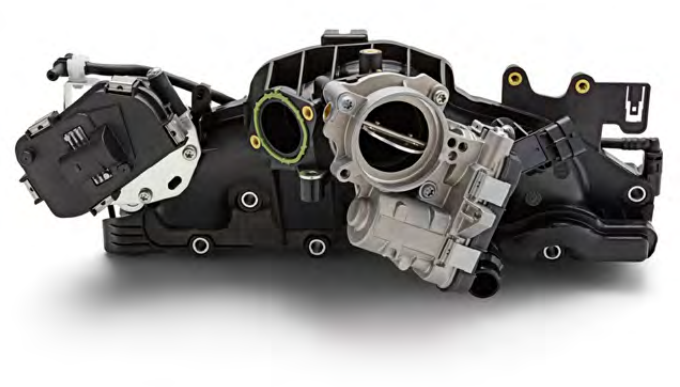
Air Intake Manifolds	page 16
Throttle Bodies	page 17
Mechatronic Actuators	page 18
Product spotlight: Matrix Actuator	page 19
Integrated transmission control systems	page 20



Air Intake Manifolds

Marelli Air Intake Manifolds provide modular air-management architectures for naturally aspirated and turbocharged engines across gasoline, diesel, LPG, CNG and multi-fuel applications.

Available in static and dynamic designs, they support precise airflow control while allowing air, fuel and thermal interfaces to be affordably integrated in a compact, lightweight package.



OEM benefits

Integrated system design - Compact integration of throttle, valves, fuel rails, injectors and related interfaces supports efficient engine performance and packaging.

Thermal integration - Water-circuit interfaces, intercooler packages and throttle-body cooling manage heat within the intake-manifold architecture.

Flexible platform application - Static and dynamic manifold designs, with fuel-compatible valves and purge-canister compatibility, help OEMs adapt to engine, fuel and emissions requirements.

Technology highlights

Static and dynamic designs with swirl/tumble control	ON/OFF or full-range actuator control with integrated diagnostics	Exhaust gas recirculation ports, water-circuit interfaces and intercooler package compatibility
Throttle-body cooling	Purge-canister circuits with ethanol and methanol-compatible valves	

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Throttle Bodies

With **more than 150 million units deployed worldwide**, Marelli Throttle Bodies provide a proven, scalable air-control solution.

The modular design is engineered for harsh operating environments, offering a robust, reliable solution for a wide range of engine configurations.

Compact, lightweight architecture supports flexible packaging and easy adaptation across vehicle platforms.



OEM benefits

Engineered for durability - Corrosion-resistant stainless-steel components, ingress protection and high-temperature variants for reliable operation in demanding environments, up to 160 °C.

Scalable integration - A broad throttle-diameter range, housing options, configurable position sensing and optional onboard control electronics allow the Throttle Body to be tailored to different vehicle platforms.

Packaging flexibility - Compact architecture and lightweight housing options help optimize packaging while supporting cost-effective platform adaptation.

Technology highlights

36-92 mm throttle diameter range	Aluminum or lightweight plastic gearbox housings	Single or dual output sensors for safety	Optional intelligent control unit with onboard microcontroller and H-bridge	PCB and PCB-less configurations
DC motors with integrated electromagnetic compatibility (EMC) filters		IP 6K9K ingress protection	High-temperature variants up to 160 °C	Range-extender configurations available

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Mechatronic Actuators



Marelli Mechatronic Actuators translate electronic control strategies into precise mechanical action across air-intake, turbocharging, thermal-management and transmission-related applications.

Each modular architecture can be tailored to specific OEM requirements and integrated into Marelli or third-party mechanical and electronic environments.



OEM benefits

Integrated powertrain control - System-level approach coordinates airflow, turbocharging, thermal valves and transmission functions more efficiently.

Seamless integration - Modular designs adapt to existing mechanical and electronic systems.

Comprehensive coverage - Broad portfolio for common mechatronic expertise across ICE, hybrid and electrified transmission programs.



Technology highlights

Variable geometry turbo system control	Air-intake swirl mechanism control	Thermal-management valve operation
Parklock control	Clutch-disconnect and lubrication functions	Smart actuator capability where required

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Product spotlight: Matrix Actuator

Marelli's new modular, brushless Matrix Actuator supports smart control of a wide range of transmission applications, from e-axles to DCT and DHT for hybrid and electric vehicles.

Featuring a single base module with integrated electronics, the Matrix Actuator handles oil cooling, lubrication, actuation and high-pressure hydraulic supply on demand.

Its modular architecture streamlines integration, lowers development costs and offers compatibility with 12 V, 24 V and 48 V platforms.



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Integrated transmission control systems

Marelli's integrated transmission control systems coordinate mechatronic control of gearing and clutch systems, ensuring enhanced drivability for modern drivetrain architectures.

The systems are available with Marelli transmission control logic or can be integrated with third-party software modules. Cybersecurity-ready design and over-the-air (OTA) capability support secure connected operation across the vehicle lifecycle.



Proven in global OEM projects, Marelli's integrated transmission control systems help OEMs evolve established ICE platforms into cost-effective hybrid powertrains.

OEM benefits

Adaptable to multiple transmissions - Compact, modular and cost-effective application for Dedicated Hybrid Transmissions (DHTs), Dual-Clutch Transmissions (DCTs), Hybrid Automated-Manual Transmissions (H-AMTs) and range-extension strategies.

Easy integration - Stand-alone mechatronic control units can be integrated with existing transmission hardware and customer-developed software.

Improved drivability - Smooth gear and clutch engagement, plus support for refined handover between combustion and electric drive modes.

Flex-fuel compatible - Adaptable to different fuel characteristics, including CNG/gasoline bi-fuel operation, helping maintain drivability across regional powertrain programs.

Safety and security ready - Supports ISO 26262 functional safety and cyber-secure connectivity, including secure OTA updates.

Technology highlights

Compact mechatronics for DHT, DCT and H-AMT applications	Position and force control of synchronizer sleeves	Dedicated Hardware Control Unit (HCU) microprocessor cores for transmission-control logic
Mechatronic or stand-alone control-unit architecture	Marelli or customer-developed software integration	Cyber-secure OTA software capability

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MARELLI: ADVANCING SUSTAINABLE PROPULSION WORLDWIDE

In an automotive landscape defined by shifting regulations and regional requirements, Marelli's long-term commitment to internal combustion helps OEMs strengthen ICE portfolios through efficient, adaptable and cost-effective solutions that get to market fast.

COMPLIANCE & EFFICIENCY

Advanced fuel and air management technologies designed to help OEMs improve combustion efficiency, reduce emissions and meet evolving regulatory requirements.

Key outcomes

- Improved fuel efficiency
- Reduced emissions
- Enhanced combustion performance
- Hybrid powertrain readiness

THERMAL PERFORMANCE

Integrated thermal management solutions that optimize heat transfer, improve system efficiency and support increasingly compact vehicle architectures.

Key outcomes

- Efficient thermal management
- Enhanced energy efficiency
- Compact, lightweight designs
- Optimized heat pump performance

GLOBAL SCALABILITY

Global engineering expertise combined with local development and manufacturing capabilities to support diverse market requirements and accelerate implementation.

Key outcomes

- Regional market adaptation
- Cost-effective solutions
- Proven production capability
- End-to-end customer support

From advanced fuel and air management to thermal optimization and regionalized development, Marelli enables cleaner, more efficient and more sustainable mobility solutions worldwide.

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Innovation @Speed.

At Marelli, we believe speed is the new currency in automotive. In a world defined by shifting consumer expectations, rapid tech evolution and intense competition, getting to market faster isn't just an advantage — it's essential.

Marelli empowers automakers to move with speed and purpose. As a trusted technology partner, we offer scalable platforms, software-defined vehicle enablement tools, production-ready solutions and fast innovation cycles designed to shorten development timelines and unlock early market opportunities.

We enable speed-to-market in four distinct ways:

- **Platform Products** – Tiered, modular hardware and software solutions engineered for speed, scalability, and smart customization.
- **Software-Defined Vehicle Enablement Tools** – Supporting future-focused E/E architectures with flexible hardware, decoupled software, and cloud virtualization tools that accelerate development.
- **Ready-to-Offer Technologies** – Proven, production-ready innovations built for immediate integration and impact.
- **Minimum Viable Product Innovation** – From concept to working prototype in as little as 90 days, our agile innovation process enables co-creation with automakers for rapid product development.

This brochure highlights how Marelli's comprehensive ICE product portfolio, built on a system integration approach, enables OEMs to enhance efficiency, support hybridization and adapt to multi-fuel strategies through scalable, ready-to-offer solutions that optimize performance, reduce emissions and accelerate time-to-market.

Let's start the conversation

Contact us at **propulsion@marelli.com** or visit marelli.com
to discover how we can support your next ICE program today.